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THE SOIL ANIMALS IN AN OAK-WOOD WITH DIFFERENT TYPES OF HUMUS FORMATION

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A brief preliminary account is given of a comparative study of the numbers of certain saprophagous and predacious animals, and Acarina and Collembola, occurring in calcareous and acid mull (moder) and mor humus forms in oak woodland. Present results indicate that in contrast to the situation in calcareous mull, saprophagous animals (excluding Acarina and Collembola) are relatively scarce in acid mull and mor. The roles of these categories in soil processes are discussed in the light of these findings.

THE decomposition of litter in forests may lead to a number of types of humus formation including calcareous mull, acid mull* and mor. The reasons for the development of these forms must be sought in the composition of the bacterial, fungal and animal populations of the soil. This composition is dependent on the species composition of the litter material, the characteristics of its components, on the physical and chemical characteristics of the soil, and the climate of the region (MÜLLER, 1879).

The site for this study is in the Hackfort Oak Forest and is a small oak coppice (*Quercus robur* L.) partly mixed with birch (*Betula verrucosa* Ehrh.), Aspen (*Populus tremula* L.) and Alder (*Alnus glutinosa* Gaertn.), situated 5 km east of Zutphen, Gelderland, the Netherlands. In this woodland, the soil of which has never been disturbed by man, three humus forms have developed which may be designated calcareous mull, acid mull and mor.

In the calcareous-mull area the litter is decomposed within a year, and the humus is mixed thoroughly with the mineral particles in the upper horizon, filling the spaces with a yellow-brown substance. The acid-mull site also shows a rather complete break-down of the litter but litter fragments and animal excrements—to a varying degree—remain concentrated in the upper horizon. Some humus fills the spaces between the soil particles and some is in the form of separate brown elements. In the mor area, litter break-down is not completed within a year; the amount remaining varies depending on the decomposition conditions during the period since leaf fall. Thus, litter in a widely varying degree of decomposition, animal excrements and amorphous humus, form a rather thick layer on top of the mineral soil. In the soil of this site the humus is mainly present as characteristic blackish-brown elements.

* Approximately equivalent to the moder humus form—Ed.

These different humus forms in the same woodland offer a unique opportunity to study the reasons for the differences in humus development. Morphological, physical and chemical studies of the soil, and investigations of the bacteria, fungi and fauna have been carried out for a number of years. These investigations have not, however, reached the stage where causal relationships can be adequately discussed*. The object of the present paper is to compare the numbers of certain members of the soil fauna present in these humus forms and to consider the possible causes and effects of these differences.

SAMPLING PROCEDURE

On representative areas of about 200 m^2 in each site, 18 sampling units (area 0·01 m^2 and 5 cm deep) were obtained on five occasions in 1957 (spring, twice during the summer, in the autumn before leaf fall and in the winter), and were extracted in Tullgren funnels. Incidental sampling to a greater depth indicated that, even in the mull site, more than 80 per cent of the more numerous species occurred in the uppermost 5 cm of the profile.

It is a well-known fact that the Tullgren-funnel technique is not equally efficient with all animal groups; Enchytraeidae and dipterous larvae, for instance, are extracted less efficiently than Diplopoda and Staphylinidae. These difficulties also apply within an animal group when different substrates are sampled but in this case the differences are of only minor importance.

QUANTITATIVE COMPARISONS OF THE THREE SITES

As it is not strictly valid to express the numbers of different animal groups on an areal basis without applying correction factors, use is made of the triangular–diagram method of presentation, used by petrologists, where the numbers of animals in the three humus forms are expressed in proportional form. In *Figure 100* the number of a particular animal group obtained from one site on all sampling occasions are expressed as a percentage of the total of that group recovered from all sites, and this percentage is proportional to the length of a perpendicular line drawn from a point on the side of the triangle subtending the angle labelled with that humus form. Most of the animals considered here have been placed in saprophagous and predacious categories but it should be stressed that these groupings are rather arbitrary and refer to the prevailing food habits.

It is clear from *Figure 100* that the saprophagous species considered (●) are relatively scarce in the mor. In acid mull only two groups prevail (*I* and *J*; Orthocladiinae sp. and Isopoda) but in the calcareous mull there are five groups of saprophagous animals (*A-E*; *Enoicyla pusilla* (Burm.), tipulid larvae, Pulmonata, Diplopoda and larvae of the Nematocera), representing more than 50 per cent of the total population for that humus form. Most of the categories of predacious animals (○) lie in the centre of the triangle (*L-S*) indicating that they are rather evenly distributed among the three sites. In the case of the Acarina and Collembola only one sampling was carried out

* Details of a survey of the fungous flora present in the soil of this woodland have been published recently (WITKAMP, M.) Seasonal fluctuations of the fungusflora in mull and mor of an oak forest. *Meded. Inst. Toegep. biol. Onderz. Nat.* No. 46, 1960, pp. 51)—Ed.

(summer 1957), and a smaller sampling area was used for these groups. The proportions of all the mite groups (*V-Y*) were much higher in mor than in the other sites. The Collembola (*Z*), on the other hand, were more uniformly distributed among the sites.

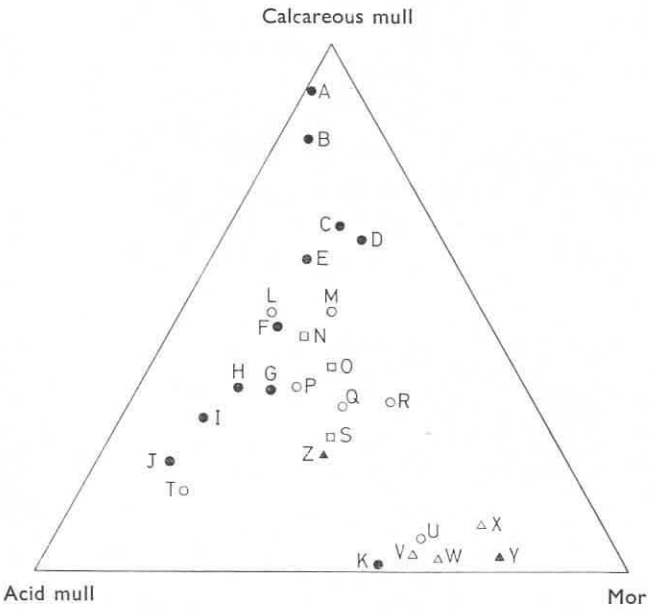

Figure 100. The relative abundance of certain saprophagous (●) and predacious (○) animal groups, micro-arthropods (▲, △), and species with varied food habits (□) including fungivorous species, in calcareous and acid mull and mor sites in oak woodland. The total number obtained from each humus form, expressed as a percentage of the total for all sites, is proportional to the length of a perpendicular line drawn from a point on the side of the triangle subtending the angle labelled with that humus form.

A, larvae of *Enoicyla pusilla* (Burm.) (Trichoptera—Limnephilidae); *B*, larvae of Tipulidae (Diptera—Nematocera); *C*, Pulmonata; *D*, Diplopoda; *E*, larvae of Nematocera (Diptera); *F*, Enchytraeidae; *G*, Lumbricidae; *H*, Protura; *I*, larvae of Orthocladiinae (Diptera—Chironomidae; *J*, Isopoda; *K*, *Campodea* sp. (Diplura—Campodeidae); *L*, larvae of Dolichopodidae (Diptera—Brachycera); *M*, Carabidae (Coleoptera—Adephaga); *N*, adults and larvae (*O*) of Staphylinidae (Coleoptera—Polyphaga); *P*, Araneae; *Q*, larvae of Rhagionidae (Diptera—Brachycera); *R*, larvae of Cantharidae (Coleoptera—Polyphaga); *S*, other Coleoptera; *T*, Lithobiidae and Geophilidae (*U*) (Chilopoda); *V*, Mesostigmata, Acaridiae (*W*), Trombidiformes (*X*) and Oribatei (*Y*) (Acarina); *Z*, Collembola.

Figure 101 compares the distribution of the Lumbricidae, Geophilidae and Tipulidae in the three sites on a seasonal basis. In the case of the Lumbricidae (*Figure 101, A*), the variation throughout the year is rather large, and this may possibly be due to differences in vertical distribution in the different seasons. With Geophilidae (*B*) and Tipulidae (*C*) the points are rather close to one another, and the same is true of the majority of the groups collected in sufficient numbers. If the material is identified at species level, which was

done only in a few cases, the preference of the species with respect to the three humus forms can be demonstrated. However, for an evaluation of quantitative ecological relationships the grouping of species with similar food habits seems advantageous.

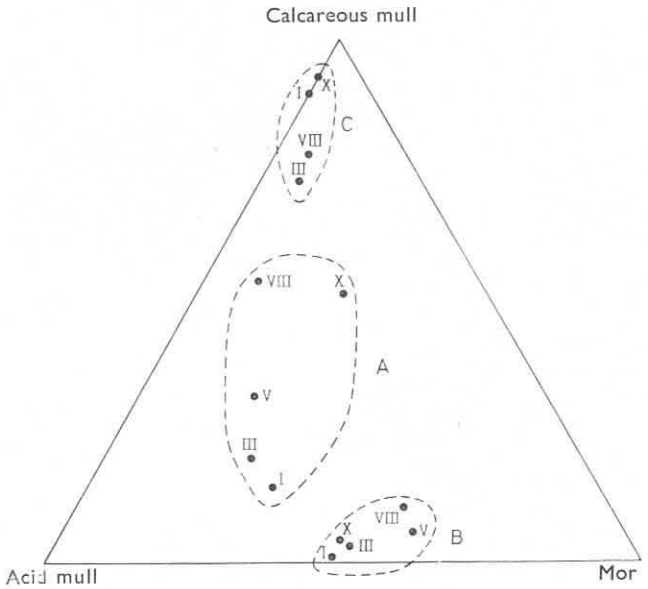

Figure 101. The relative abundance of Lumbricidae (*A*), Geophilidae (*B*, Chilopoda) and larvae of Tipulidae (*C*, Diptera—Nematocera) on each sampling occasion in calcareous and acid mull and mor sites in oak woodland (see also *Figure 100*). The roman numerals represent the months when sampling took place.

DISCUSSION

The smaller number of species and individuals of the soil macrofauna in the mor site may be ascribed to the following causes. The somewhat higher elevation (maximum difference in height is 65 cm) of this area may have an unfavourable influence on the humidity conditions of the soil, and the more rapid desiccation of the litter occurring there renders it unsuitable as food for a longer period of time. The litter layer consists only of oak leaves and these are less readily eaten than Alder, Aspen or even birch by most species. The differences between the macrofaunal groups in the acid and calcareous mull areas are of less importance. These differences may be due to the better humidity conditions in the latter site, the higher calcium content of the soil and the greater variety of litter components, which include the nitrogen-rich Alder.

The main effect of litter-feeding members of the Lumbricidae, Isopoda, Diplopoda and many insect larvae is the mechanical break-down of the litter into macrofragments (uneaten residues) and microfragments (excrements). These are attacked by smaller animals and a variety of micro-organisms, the species composition of which is quite different in mull and

mor. It has been stated that in calcareous mull the excrements of soil animals disintegrate much more quickly than in mor and that in acid mull the rapidity of disintegration occupies an intermediate position.

In the calcareous mull, which has the largest number of saprophagous animals, a rather complete break-down of the litter occurs within a year. In contrast, the acid mull has a smaller number of saprophagous species, and a layer of macrofragments mixed with excremental remains will still be found at the end of this period of time. The mor site has the smallest number of saprophagous macrofauna, and over the same period some of the litter remains practically unattacked by animals, while the remainder is comminuted into macrofragments and excrements. In this situation, despite a dense fungal growth and high numbers of micro-arthropods, decomposition goes on slowly and is perhaps much more dependent on weather conditions than is the case in the calcareous and acid mull sites.

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